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Review article

Proximal repair in acute type A aortic dissection: The dark side of the root

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Abstract

There is no agreement regarding the best treatment for proximal repair in acute type A aortic dissection. Isolated replacement of the ascending aorta has been shown effective but can leave patients at a higher risk of further aortic procedures. The interpretation of the results coming from the literature is difficult because of the great variability of the clinical scenarios and the anatomic extension of the dissection. The analysis of the risk factors suggests that the presence of the underlying root pathology and a more extensive involvement of the aortic root should address the surgeon towards a more radical proximal resection.
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Keywords: Aorta; Aortic dissection; Aortic root

Contents

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1. Introduction

Acute type A aortic dissection is a surgical emergency invariably burdened, if left untreated, by 90% mortality at 30-day. No randomized clinical trials have ever been conducted in patients with aortic dissection but data coming from clinical experiences widely demonstrated that a prompt surgical repair is the only therapeutic option able to convert the dismal natural history of this pathology into 70%–80% chance of early survival [1]. The cornerstone of the surgical treatment includes the resection of the intimal tear, the replacement of the intrapericardial aorta and the correction of concomitant aortic valve dysfunction. The first goal of the surgical operation is the survival of the patient. Nowadays, however, advances in diagnosis, surgical techniques and perioperative care led to improved early outcomes and the new goal is the achievement of durable results in the mid- and long-term period and a reduced risk of further aortic complications.

The long-standing debate about the opportunity of providing a simple and quick procedure or a more radical resection of the entire root with the reimplantation of the coronary ostia is still open. On this ground, there is no agreement regarding the best treatment and strategy in proximal repair.

2. The real world

A trend in proximal repair of aortic dissection can be delineated considering the results from large cohorts of patients as reported in literature. Fig. 1 summarised the techniques for proximal repair as they were described (1996–2013) in 17 different institutional experiences during the period 1967–2011 and globally involving more than 5000 patients [2–18]. In 95% of the cases, the replacement of the ascending aorta was associated with aortic root reconstruction (70%) or replacement (25%). The simple excision of the intimal tear followed by the direct suture of the ascending aorta is unusual and generally abandoned. Ascending aorta replacement and isolated aortic valve replacement accounted for 5% of the cases. This approach is generally reserved in presence of aortic leaflets abnormalities, calcification and dysfunction not dependent by alterations of the Valsalva sinuses or the sinotubular junction (STJ), and it is nowadays mostly performed in patients older than 70 years. Therefore, we can delineate and consider in our discussion two major groups: patients who undergo supracoronary aortic replacement and patients who receive aortic root replacement.

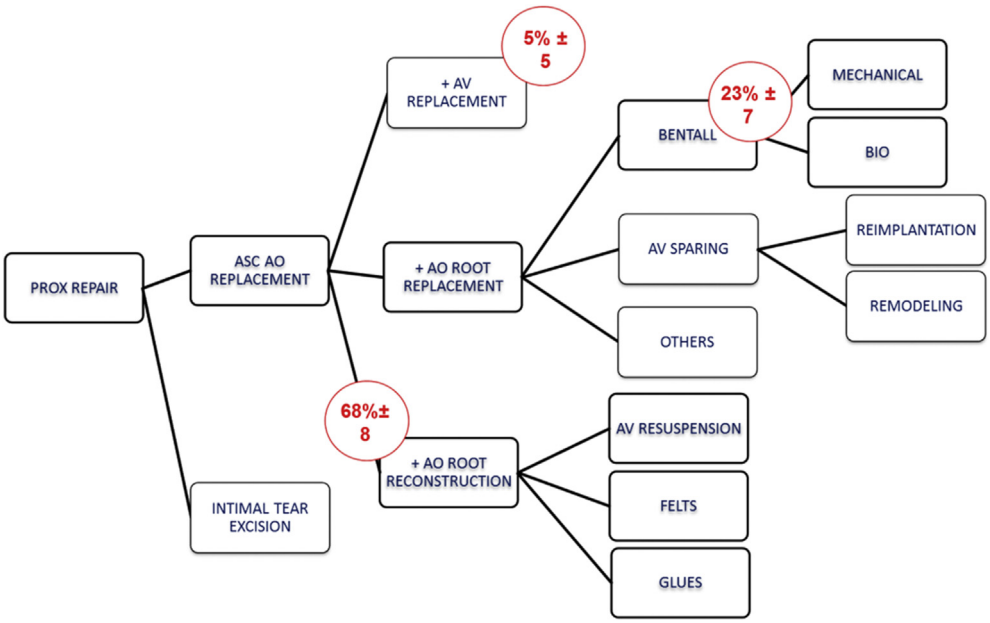

Fig. 1. Synoptic view of the surgical procedures performed for proximal repair in acute type A aortic dissection.

3. Supracoronary and aortic root replacement

The proximal repair can be carried out with an isolated replacement of the ascending aorta. The aortic wall is resected down to the STJ and the aortic root layers can be re-approximated using different techniques including the fixation with biologic glues and/or the use of strips of Teflon felts that can be placed inside and outside the aortic wall or even in between the dissected layers as a new media. The adventitia can also be everted along the border of the proximal aortic stump. The STJ is then restored and the commissures of the aortic valve can be resuspended with U stitches. In the presence of pathology of the aortic leaflets or severely distorted geometry of the root, the aortic valve is replaced with a prosthesis.

The root replacement allows for a complete resection of the sinuses of Valsalva. The aortic valve leaflets can be excised and a composite valve graft conduit is then implanted. A valve-sparing procedure is also feasible using the reimplantation (David procedure) or the root remodelling technique (Yacoub procedure). The full root replacement is completed by the re-attachment of the coronary ostia.

4. The literature and the outcomes

The replacement of the supracoronary aorta with the re-approximation of the aortic root layers and the restoration of the sinotubular junction has shown to be safe in terms of patients' survival and effective in the treatment of aortic regurgitation. Replacement of the aortic root with composite valve graft conduits has been progressively and increasingly performed in the acute setting with an acceptable in-hospital mortality and long-term durability. A difference in early survival between patients who underwent supracoronary aorta replacement and patients who had full root replacement has not been reported. This finding has been claimed as an evidence supporting the safety and effectiveness of a more conservative treatment, but, on the other hand, has been seen as the proof that a more radical resection can be offered safely despite its complexity in an emergency setting [9,11,17,19–21]. The interpretation of these results however is difficult. They come from studies that were retrospective in nature and with several limitations:

A. The interval times of these observational studies were usually long and include decades of improvement of surgical techniques and strategy in perioperative care.
B. The early mortality rate presents a wide range from 5% up to 30%, thus making any comparison difficult.
C. Acute type A aortic dissection has an heterogeneous presentation and it is well recognized that the clinical presentation is the strongest risk factor for early mortality.
D. The cohorts of patients who underwent a conservative or an extensive resection were generally different in terms of patients' age and clinical presentation. A selection of the patients was based on the preference of the surgeons (clinical view of the patient, personal experience), the associated malperfusion syndrome or haemodynamic instability and the anatomic extension of the dissection [11,12,19,20,22].

Similar limitations emerge when analysing the survival at long-term follow-up which nevertheless did not show any difference between these two groups of patients [17,20].

A higher rate of proximal reoperation during the follow-up has been described in patients receiving a supracoronary aorta replacement with a freedom from proximal reoperation at 5 years of 82%–100% and at 10 years ranging from 69% to 93% [3,20,23,24]. It is intuitive that the retention of pathologic tissue can predispose to an early pathologic evolution of the retained segments of diseased aorta and the development of new aortic complications. It is therefore that on this basis, some surgeons advocated a more aggressive strategy for proximal repair in order to minimize the risk of a redo procedure. Reoperation, however, has to be considered a surrogate outcome of durability of the surgical repair. Reoperation is the result of a clinical decision, which considers the condition of the patient, his suitability for a new invasive surgical procedure and prognostic expectations, and includes the availability of an imaging follow-up.

However, daily clinical practice suggests that a risk of a new proximal operation after the replacement of the supracoronary aorta for dissection repair is not negligible and it is estimated to be up to 20% in 10-years time [25].

5. Risk factors of proximal reoperation after supracoronary aorta replacement

The actual guidelines and consensus statement on aortic dissection suggest that the aortic root can be preserved in presence of an almost non dilated aortic root and in absence of an intimal tear at the level of the sinus(es) of Valsalva.

In case of a dilated aortic root, severe disruption of the aortic wall, and especially in patients with known connective tissue disorders, a full root replacement should better be performed [26,27]. However, it is difficult to clarify what is a "severe involvement or disruption of the aortic root".

The analysis of the associated factors and the pathologic mechanisms leading to a proximal aortic reoperation after supracoronary repair of acute type A aortic dissection can better characterize some clinical and anatomical scenarios at high risk for a redo proximal procedure.

Several risk factors of proximal reoperations after supracoronary aorta replacement have been recognized in literature and they can be categorized in:

A. Demographic: Marfan syndrome; Young age;
B. Anatomic: Aortic annulus diameter >27 mm;
C. Pathologic: Dissection of all 3 sinuses of Valsalva; Coronary artery dissection;
D. Functional: Cardiac malperfusion; Aortic regurgitation degree moderate to severe;
E. Technical: Use of Glues; Aortic Valve resuspension.

However, this findings from retrospective studies not always including data and details about the preoperative anatomy of the aorta, the extension of the dissection and the degree of involvement of the aortic root. For this reason, aside from the evidence of the role of underlying connective tissue disorders, they cannot be taken as absolute indications for a more radical procedure.

A. Marfan syndrome, emerged in several experiences as a strong predisposing factor at medium term for significant aneurysmal evolution or development of new aortic complication in a retained dissected or dilated aortic root. The rate of proximal reoperation was reported up to 50% at 10 years [28]. Similarly, young patients experienced a higher rate of proximal reoperation [29]. This problem should not be considered strictly in the light of the longer survival expectancy, the prolonged exposition to aortic complication or an easier acceptance for a redo procedure. Patients <40 years old, operated on for type A aortic dissection, show usually a more dilated proximal aorta and aortic annulus and anatomic features similar to Marfan patients [30]. Alongside the well-characterized syndromic tissue disorders, there is increasing evidence about the role of further genetic mutations determining alterations of structural and metabolic aortic wall properties and leading to higher risk of development of thoracic aortic aneurysm and related complications at younger age. These patients represent up to 20% of all thoracic aortic aneurysm cases. They do not have any evident syndromic feature and could show a familial inheritance (non-syndromic familial thoracic aortic aneurysm) or present as isolated case of aortic disease in very young age [31,32]. Furthermore, in younger patients the dissection flap presents a more extensive involvement of the aorta and a proximal intimal tear is more frequent [12,33].
B. The presence of an enlarged aortic annulus diameter (>27 mm) has been proposed in literature as a risk factor for reoperation, thus justifying a more aggressive attitude towards the replacement of the aortic root [34]. The presence of pre-existing aortic abnormalities can sustain a faster root dilatation or development of aortic valve regurgitation.
C. A more pronounced root involvement reasonably and intuitively may support a pronounced progression of the aortic pathology. The dissection of all aortic sinuses [35] or its extension into the coronary ostia [2], seem to predict a high risk for reoperation; the aneurysmal evolution is more pronounced in a dissected aorta than in case of atherosclerotic aneurysm [36]. Similarly, patients with preoperative cardiac malperfusion, seen as a marker of severity of dissection of the coronary sinus(es), experience a higher rate of proximal aorta redo procedures during the follow up [37].
D. The use of glues has been questioned in the development of necrosis of the aortic media. Histology evidence is available for the gelatin-resorcinol-formaldehyde (GRF) glue, discordant data was presented for the human fibrin glue. Alongside a possible active role of glues in promoting tissue necrosis, we should keep in mind that a large re-approximation of the aortic wall layers with glues means also a wider tissue disruption and a more extensive proximal involvement [38,39]. We can apply the same consideration to the finding that the resuspension of the aortic valve is associated with a higher rate of proximal reoperation. This technique is more likely to be performed in case of a flap entering the sinu-tubular junction or the sinus(es) of Valsalva, therefore in patients with a proximal extension of the aortic dissection [40].

E. The presence of preoperative moderate to severe aortic regurgitation has been found to be an independent risk factor for proximal reoperation at mid-follow-up [4,8,41]. The extension of the dissection flap into the sinus(es) of Valsalva causes the loss of annular support and leaflets(s) prolapse. Although patients with leaflet prolapse have significantly greater degree of aortic annulus dissection, the presence of the prolapse itself is enough to justify a severe aortic valve regurgitation even when related to a limited proximal dissection [42]. Significant valve dysfunction may be consequence of leaflet(s) tethering secondary to STJ dilatation or of mal-coaptation due to diastolic impingement of the dissection flap into the aortic orifice [43] (Fig. 2). In absence of clear evidence and description of the mechanism leading to aortic insufficiency, the degree of regurgitation alone should not be considered a risk factor of proximal reoperation. It can be a marker of a more pronounced involvement and extensive disease of the aortic root.

6. Characterizing the severity of root involvement

All the above discussed variables and evidence translate in an obvious consideration that the anatomic condition of the aortic root should guide the proximal repair [40].

The presence of an intimal tear crossing proximally the STJ or at the level of the sinus(es) of Valsalva has to be considered a sign of severe root involvement: the aortic tissue should be resected and replaced. The involvement of the coronary ostia is better treated with a full root replacement looking not only at the durability of the aortic repair but also at the possibility of solving or preventing myocardial malperfusion. Some experiences reported a partial root replacement with the resection of the sinus of Valsalva involve by the intimal tear, this technique can stabilize the aortic root providing a normal function of the aortic valve [44].

After the onset of the dissection we can anticipate an increase of the diameter of the aortic segments because the outer layer has a tendency to suddenly dilate [45]. This change and the usual lack of pre-dissection imaging do not allow a precise definition of the aortic root size. Different policies considered a diameter >[40–50] mm as a cut-off for a more radical resection. This finding however should be coupled with the life expectancy of the patient. The growth rate of the preserved aortic root after dissection repair is not different from the non-dissected aneurysmal aorta, for

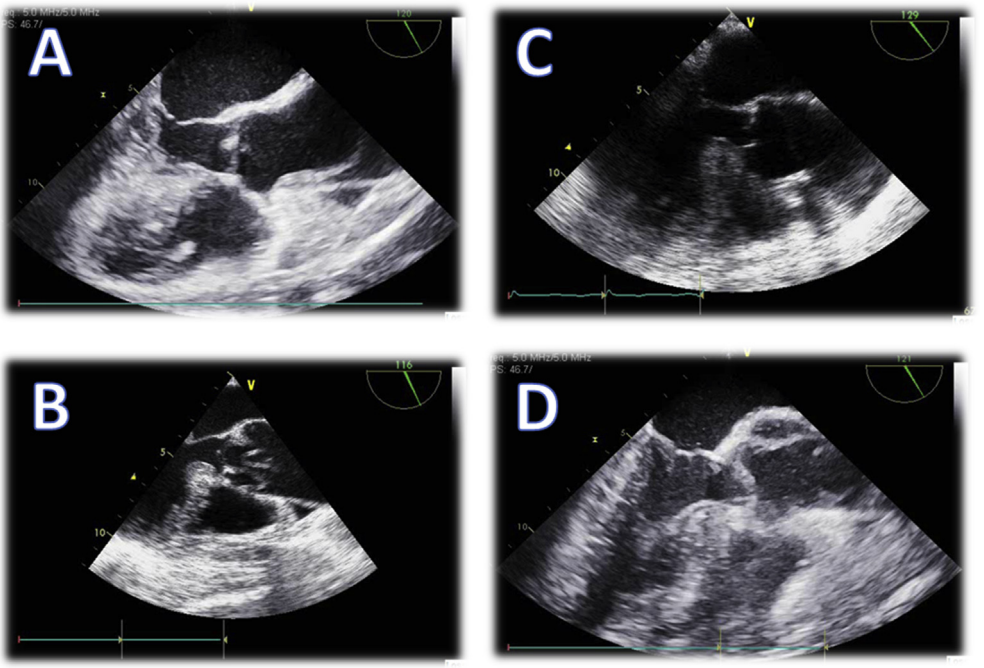

Fig. 2. Involvement of the aortic valve in type A aortic dissection. A: the dissection flap does not enter into the aortic root. B: the dissection flap cause AV obstruction in diastole. C: dissection of the aortic root causing the prolapse of the aortic valve cusp. D: dissection of all the sinuses of Valsalva.

patients with a diameter <50 mm one could expect a significant dilatation in the following years and especially in the elderly this finding did not affect the prognosis [46]. However, and enlarged root can cause technical difficulties in the restoration of a normal and durable aortic valve competency. Similarly, the presence of dissection involving more than 2 commissures is challenging in the re-establishment of an adequate coaptation of the valve leaflets.

An anatomy-based characterization of the root involvement was provided by Sun et al. and validated in 257 patients who underwent repair of acute type A dissection in the period 2003–2008 [18]. They considered 3 different subgroups of patients with no, mild to moderate and severe root involvement according to the root size, the feature of the STJ, the dissection of the coronary sinus(es), the detachment of the aortic commissure(s) and the presence of aortic regurgitation. In about 70% of the cases, the patients presented absent (46%) or limited (24%) involvement of the aortic root. They were treated with a conservative approach in more than 90% of the cases, while in presence of a dilated aortic root and full root dissection, a root replacement was performed. This experience showed that the repair according to root anatomic subtypes was safe, but, unfortunately, the limited follow-up did not provide any information about durability and possible failure in the mid-long-term period.

7. When to replace the aortic root

Considering the evidence coming from literature an algorithm of treatment is proposed as showed in Fig. 3. In presence of a normal and non dissected aortic root a supracoronary replacement is the proper surgical approach. The reconstruction of the aortic wall and the correction of possible concomitant aortic regurgitation is feasible in presence of a partial involvement of the sinus(es) of Valsalva. A full root replacement should be better performed in presence of a tear in the aortic root and dissection of the coronary sinus(es). An enlarged root required a radical resection. In presence of a bicuspid aortic valve with non calcified and non prolapsing leaflets and non dissected aortic root, the supracoronary replacement is feasible. Consensus exists regarding the opportunity of a more radical resection in patients with connective tissue disorders especially Marfan patients. A similar strategy as previously discussed should apply also to young patients. The full root replacement should not be denied based on the advanced age. Despite less important on the prognostic ground, when indicated, a radical procedure in the elderly can provide a better early outcome as it did not emerge as a risk factor for early mortality in this subgroup [47].

The vast majority of results with full root replacement came from experience with the Bentall procedure and its modifications. Recent studies validated the safety and effectiveness of valve sparing aortic root procedure. The evidence is still limited and mainly related to single-institutional experiences [25]. This technique fulfils the need for a

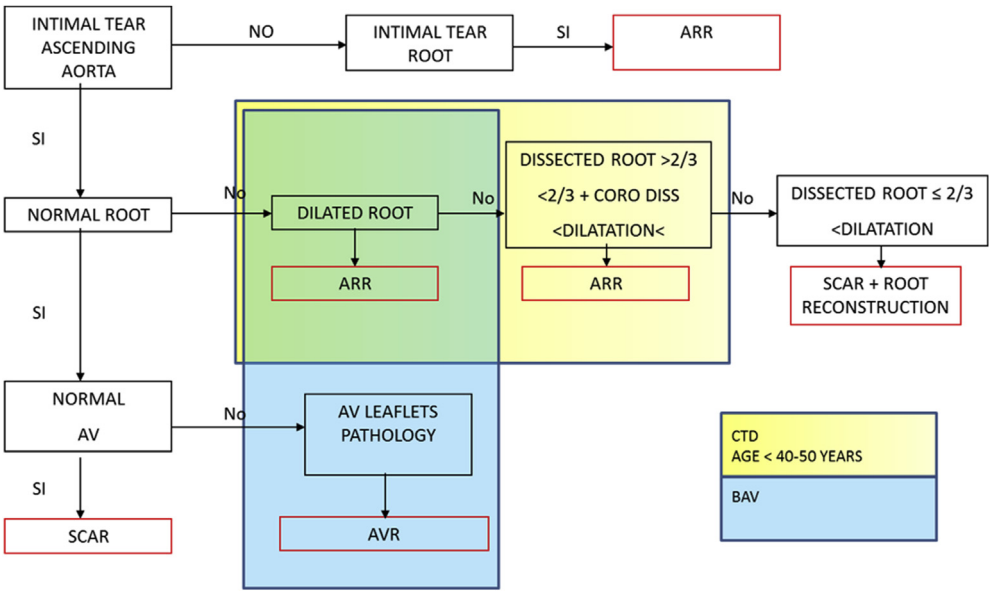

Fig. 3. Algorithm based on the anatomic extension of the dissection and clinical characteristics of the patients.

radical resection and treatment of concomitant aortic regurgitation, however, the advantages in acute dissection are limited when compared with the results in patients with atherosclerotic aneurysm. The average survival expectancy of patients who survived the acute phase of type A acute aortic dissection does not provide the benefits of a significant reduction of ischaemic and haemorragic events associated with the implantation of a mechanical prosthesis or the avoidance of reintervention for bioprosthesis failure [25]. Younger patients (<50 years old) with an expected survival of 80%−90% at 10-year could have major advantages from a valve sparing aortic root replacement and can be considered potential candidates for this technique.

8. Lesson from reoperations

Aortic reoperation can be performed safely in an elective setting [40]. This evidence should be considered while planning the strategy for aortic dissection repair. The resection limited to the ascending aorta for proximal repair leaves undoubtedly many patients at risk for future procedures but this does not translate automatically in a worse composite survival. Proximal aortic reoperation after supracoronary dissection repair includes mostly a procedure of full root replacement. A regular imaging follow-up can provide the evidence of an enlarging aneurysm or the occurrence/recurrence of severe aortic regurgitation before the development of large mediastinal lesion or heart failure. In this setting, the mortality is acceptable (3−5%) and the long-term outcome favourable. A minority of the patients receiving supracoronary aorta replacement experience infectious complications, which are with aortic false aneurysm the main cause of reoperation after full root replacement. These conditions are more serious leading to difficult and high risky operation with an expected mortality higher than 10%.

9. Conclusion

The proximal repair of the thoracic aorta should be guided by the characteristics of the aortic root disease. We should evaluate the presence of pre-existing aortic root pathologies and underlying aortic wall diseases, the site of the intimal tear and the mechanism of the concomitant aortic valve regurgitation and the possibility of achieving an adequate valve competence. The need of an extensive re-approximation of the aortic root layers is a marker of a more pronounced disruption, which can promote an aneurysmal evolution or dysfunction of the aortic valve. Younger patients deserve a more radical resection; early onset dissection during life should be regarded as the manifestation of an unrecognized probably non-syndromic aortic wall disease. A tailored approach in acute dissection surgery can guarantee satisfactory early outcomes and minimize the risk of reoperation at mid-long-term.

Conflict of interest

No conflict of interest.

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